





COMMUNICATIONS AND NETWORKING TECHNOLOGIES

Think of BMDO technology
transfer the next time you

- Call someone from a portable telephone.
- Make a telephone call from or to a very remote location.
- Need a fast way to send a large amount of digital information across town.
- Access the Internet.

WIRELESS, LIKE YOU NEVER HEARD IT BEFORE

Intelligent, adaptive signal processing can enhance wireless communications, helping to increase system capacity and improve signal quality.



■ ArrayComm's IntelliCell® technology is the driving force behind a new generation of intelligent base stations (pictured above) soon to be deployed widely in the Japanese market.

Take a mobile car phone, and shorten its range. What you have is a lot like the service provided by low-mobility wireless systems, the next big thing in telecommunications. These systems are intended for customers who need “walkaround” wireless access in a limited geographic area, such as a local neighborhood or business campus.

Unfortunately, some drawbacks, such as interference and capacity, have limited the growth of this wireless service. For example, in densely populated areas, crosstalk from other cellular signals can seriously degrade signal quality. Multipath interference, caused by the physical features of the urban landscape, also distorts signals.

ArrayComm, Inc. (San Jose, CA), is marketing systems that enhance wireless communication systems by maximizing signal quality while minimizing interference. Using BMDO-funded advanced radar signal-processing technology that originated at Stanford University, ArrayComm has developed a suite of algorithms to discriminate between multiple radio signals operating on the same frequency. The technology, called IntelliCell®, selectively receives radio-frequency energy from, and transmits it to, multiple users in the same “cell” simultaneously.

Virtual wires. The IntelliCell process creates “virtual wires” that establish and maintain optimal connections between each subscriber and a base station. The key technologies consist of a methodology for siting multiple transceiver antennas, algorithms for processing the signals from the array, and software to control the signal processing functions. By applying intelligent control of the individual antennas, the system can selectively transmit radio frequency (RF) signals to the receiver; it can also selectively “listen” to the mobile transmitter, mitigating interference signals from other RF sources.

“IntelliCell techniques dramatically enhance wireless service quality, coverage, and capacity on a real-time basis,” says ArrayComm’s Dr. Richard Roy, the scientist who spearheaded the original technology development at Stanford. “The result is an unprecedented savings in infrastructure and operating costs.” ArrayComm reports that because fewer base stations are needed, IntelliCell can help reduce infrastructure investments by up to 50 percent over conventional

base station approaches. Operating costs, such as those associated with power and equipment maintenance, would also be reduced.

In its first commercial application, IntelliCell technology is being deployed in Japan's Personal Handyphone System (PHS), a low-mobility personal communications system introduced in 1995. PHS is marketed on its low-cost, high-quality service; lightweight handsets; and long battery life—all attributes that IntelliCell technology can further enhance. Collaborating with Kyocera Corporation in Japan, ArrayComm initially incorporated IntelliCell technology into 30 base stations in Tokyo for Kyocera's customer, DDI Pocket Telephone, the largest PHS service provider in Japan. Test results pointed to superior voice quality with an estimated four- to five-fold increase in network capacity. Full-scale deployment is under way.

Ever so popular. With the success of the testing program, ArrayComm and Kyocera recently finalized an agreement to manufacture and commercialize IntelliCell-equipped base stations. DDI also placed an order for 1,000 such units. DDI Pocket provides service for an estimated 3.5 million Japanese subscribers, making it the largest PHS carrier in the world. In addition, Kyocera currently ranks first of 16 manufacturers in the PHS handset market, with a 25 percent share.

In the longer term, ArrayComm projects an expanding market share for wireless local loop (WLL) systems to more than half the entire wireless business volume by the year 2000. WLL products are intended for rapid deployment of local telephone services in less-developed countries lacking wire-based telephone switching networks. They enable many telephones in a local area to communicate using a single base station. Because WLL can be easily installed, it is particularly attractive for use in rural settings.

ArrayComm is now marketing an IntelliCell WLL system called IntelliWave especially for this remote market. The company has established relationships with strategic partners in Asia, Europe, and South America. For example, it recently signed a partnership agreement with Brazil-based Zetax Tecnologia S.A. (ZETAX) that establishes ZETAX as a distributor of ArrayComm's IntelliWave product in Brazil.

■ For more information, contact Christine M. Oliver via telephone at (408) 428-9080 or via E-mail at chriso@arraycomm.com. You can also visit ArrayComm's Web site at <http://www.arraycomm.com>.



What Does It Mean to You?

IntelliCell technology will sound great to wireless subscribers because it reduces static and interference and ultimately lowers handset and service costs.



What Does It Mean to Our Nation?

With its performance, range, and cost advantages, IntelliCell technology could help U.S. wireless providers thrive in this intensely competitive market.

Tech Trivia

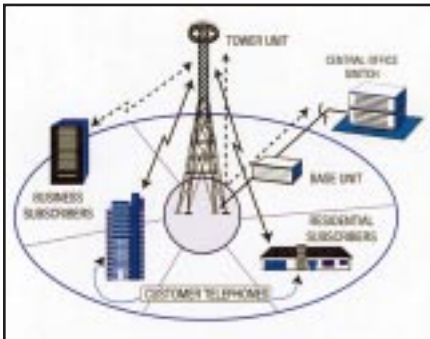
At the Olympic games in Atlanta, Georgia, what were the 21 cellular stations that roamed the premises called?

- A. COWs
- B. HOGs
- C. LAMBS
- D. PIGs

For the answer, see page 72.

THE WIRELESS FUTURE IS—GUINEA?

A fixed wireless telephone network can help telecommunications companies reduce infrastructure costs in rural areas of developing countries.



■ Glynn Scientific's wireless telephone network (pictured above) can serve rural areas of any size up to 11,300 square miles.

Despite technology advances, tens of millions of people in developing countries have little or no access to basic telephone services. One-quarter of the world's population of 5.9 billion lives in countries where there is less than one phone line for every 100 people, which the International Telecommunications Union, a United Nations agency, defines as "minimum access." In countries like Afghanistan, Guinea, and Somalia, there is just one telephone for every 500 people.

In developing countries, roughly two-thirds of the population lives in rural areas, making it costly for telecommunications companies to justify their infrastructure investment. In these countries, the cost to connect each subscriber could easily surpass \$1,000, nearly double the cost in more developed nations.

Glynn Scientific, Inc. (GSI; Annapolis, MD), is creating a new wireless network technology called Towerphone™ that may reduce new subscriber connection costs to as low as \$200. By combining an innovative communications signaling technology with fixed towers, this network technology can provide low-cost, high-quality telephone and data services to more than 1 million subscribers. Single-tower Towerphone networks can serve areas of any size up to approximately 11,300 square miles. Service will be provided using low-cost subscriber phones.

Bandwidth economy. The key to Towerphone is its communications signaling technology called convolutional ambiguity multiple access (CAMA), which offers several advantages in multiple-access telecommunications environments. CAMA can permanently assign unique codes to all subscribers, reducing the amount of bandwidth consumed in the call set-up process. It also offers acceptable co-channel interference performance without network-wide synchronization—a major simplification in network design. GSI developed CAMA while working on advanced phased-array radar technology for BMDO's Arrow and Corps Surface-to-Air Missile projects and on other defense projects.

Towerphone will be attractive to telephone companies looking to break into emerging telecommunications markets in developing countries around the globe. "With a projected subscriber connection cost of \$200, Towerphone will minimize infrastructure outlay and help bring in profits sooner for telecommunications companies," says Tom Fullerton, GSI's vice president of business

development. "You won't get this level of pricing with cellular or very small aperture satellite terminal (VSAT) technology. Cellular pundits say a \$500 subscriber connection cost is possible within the next few years. And the current subscriber connection cost for VSAT reaches between \$3,000 and \$5,000."

Mr. Fullerton also points out that Towerphone requires less infrastructure than cellular networks. Capable of covering the same area as a Class A television station, Towerphone requires only one fixed tower, while cellular service requires "a whole bunch." The television station reference is appropriate because Towerphone will use existing television transmission towers for mounting equipment wherever possible. In addition, businesses and homes will not need any huge dishes or bulky equipment; the antenna will be a small, flat plate that can be easily attached to the side of a building.

On the move. GSI has developed an in-depth business plan for bringing Towerphone to market. With the assistance of an international investment banking advisory team, the company is currently seeking financing to begin product development. It is seeking \$8 million to install and test a 1,500-subscriber beta-site network in the United States or abroad.

Further leveraging BMDO-related technology, GSI has spun off a new venture company called NetSat28. In May 1997, NetSat28 received a Federal Communications Commission license to develop and launch a communications satellite to operate in the K and Ka microwave bands, averaging 28 gigahertz in uplink carrier frequency. The geostationary satellite will enable coast-to-coast, two-way communications at conventional T1 network data access rates, or 1.5 megabits per second. Based on patented optical switching technology, NetSat28 could provide as many as 175,000 two-way links simultaneously, offering speedier access to the information superhighway.

To date, the NetSat28 team has invested \$1 million of internal funds to form NetSat28, secure the Ka-band license, and continue technical development at GSI. With the satellite's launch date set for 2002 or 2003, the company is exploring relationships that will exploit this exciting capacity for both business and home use. NetSat28 seeks content and service providers who could also benefit from this network infrastructure.

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What Does It Mean to You?

Towerphone will allow Americans to communicate with people in developing countries (and vice versa) as easily as making a telephone call in the United States.



What Does It Mean to Our Nation?

New international companies anchored in the United States can be formed to market Towerphone technology to emerging telecommunications businesses in developing countries around the world.

Tech Trivia

When Alexander Graham Bell died on August 4, 1922, what happened later that day?

- A. Millions of phones went dead.
- B. He was buried holding a telephone.
- C. His wife permanently removed all telephones from their home.
- D. His native country Canada commissioned a statue to be built in his honor.

For the answer, see page 72.

LASER AIMS TO SHOOT DATA THROUGH THE AIR

Fiber-free laser communications systems allow companies to transmit data through the air, connecting multiple building sites at an affordable cost.



■ AstroTerra's newest product, the TerraLink 1000™ (pictured above), provides low-cost, fast data rate laser communications for distances under a mile.



■ A TerraLink 8-155™ (pictured above) provides high-speed wireless connectivity between the Las Vegas Convention Center and the Hilton Hotel.

The city of Santa Barbara, California, is ever vigilant to enforce strict regulations against altering historic buildings and city streets. That is what STAR Telecom, a provider of wholesale international long-distance telephone services, found out soon after the company decided to expand its corporate local area network. The city's aesthetic ordinances banned any effort to trench fiber across the street or to install large microwave antennas on buildings. Thus, STAR Telecom could not establish a network connection to its other downtown building.

Thanks to new laser communications (lasercom) equipment developed by AstroTerra Corporation (San Diego, CA), STAR Telecom established a low-cost, high-bandwidth connection between its two buildings—without disturbing the historic land and buildings. AstroTerra's cutting-edge lasercom technology, called TerraLink™, is ideal for meeting the ever-increasing demand for greater bandwidth among multiple buildings at an affordable cost. For corporate network managers, this innovation provides a new alternative to fiber, microwave, and radio frequency (RF) technologies, which in some cases can be too expensive, too complex, and too low in bandwidth.

Through the air. AstroTerra's lasercom systems use infrared (IR) laser light to transmit the 1s and 0s that make up a digital signal. This process is similar to the one that takes place inside a fiber-optic cable, but for laser communications, the light travels through the air. AstroTerra spun off its lasercom technology from a BMDO-funded project to develop a satellite lasercom transceiver, which is scheduled to be lofted into low-Earth orbit in early 1999 as part of BMDO's Space Technology Research Vehicle (STRV)-2 experiment. In STRV-2, the transceiver will be used to demonstrate communication between the satellite and the ground at 1 gigabit per second as well as to downlink IR sensor data.

TerraLink systems provide new alternatives to installing fiber-optic cable between sites. "For high-bandwidth applications such as telemedicine or video-conferencing, TerraLinks are more attractive when it is too costly or impossible to install fiber-optic cable," says Dr. Eric Korevaar, AstroTerra's founder and president. "For situations that require temporary network connectivity, such as exhibitions, conventions, sporting events, or emergency situations, high-bandwidth links can be easily and quickly provided using portable TerraLink systems. With

private corporate networks, purchasing a TerraLink can provide a very high bandwidth link between sites without the recurring costs of leased lines.”

TerraLink products offer bandwidth, operation, and security advantages over microwave and RF technologies. TerraLink systems transmit data faster than any currently available microwave or RF system. They do not require a frequency license from the Federal Government or right-of-way from the municipality involved. In addition, their IR beams are invisible and confined to a narrow path, thus making them difficult to intercept.

Several TerraLink products are commercially available. The basic TerraLink 8-155™ can transmit and receive data at up to 155 megabits per second (Mbps), with a clear weather range of up to 5 miles. The faster TerraLink 8-622™ allows a data rate of 622 Mbps—which exceeds the current bandwidth capabilities of microwave—at clear-weather distances of up to 3 miles. The TerraLink 4-155™ and TerraLink 1000™ offer the same connectivity as the TerraLink 8-155 but cost less because they are designed for distances less than a mile.

Purchases and evaluations. A number of municipal and commercial organizations have purchased or are currently evaluating TerraLink products. The San Diego County Water Authority installed a TerraLink system to establish a high-speed data link between two office buildings in downtown San Diego, California. The Authority says it saved a substantial amount of money because it avoided the costs of trenching cables across the street and leasing lines between the two buildings. Kaiser Permanente’s Technology Evaluation and Support Center is currently evaluating TerraLink for use in its health care facilities throughout California.

In addition, AstroTerra is investigating several military applications for its TerraLink technology. The company is involved in tests for ship-to-ship and ship-to-shore communications for the U.S. Navy, site-to-site communications for the U.S. Army, and unmanned aerial vehicle communications for the U.S. Air Force.

Another potential market, space communications, may be pursued if BMDO’s STRV-2 demonstration of AstroTerra’s lasercom technology is successful. To attract prospective customers, AstroTerra is building a lasercom evaluation model with a data rate greater than 1 gigabit per second for satellite-to-satellite and satellite-to-ground links.

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What Does It Mean to You?

Lasercom systems will establish secure, high-bandwidth connections between two or more nearby buildings, allowing workers to communicate more efficiently with each other.



What Does It Mean to Our Nation?

Lasercom systems will help municipalities preserve historic streets and buildings while allowing companies to expand communications networks.

Tech Trivia

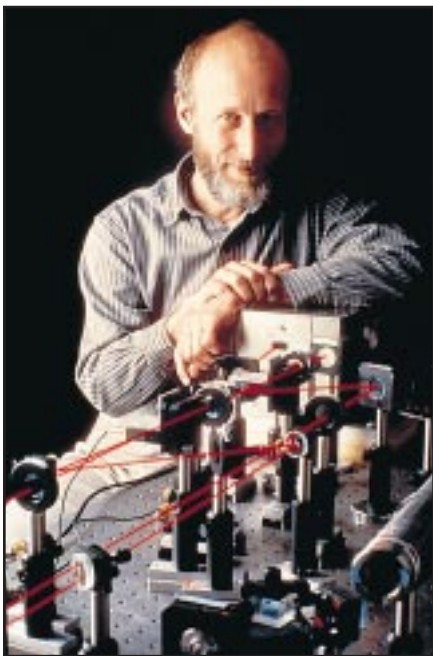
In which of the following novel applications have infrared lasers not been used?

- A. Security
- B. Eye surgery
- C. Aircraft inspection
- D. Three-dimensional imaging

For the answer, see page 72.

OPTICAL SWITCH PUSHES THE DATA ENVELOPE

An optical switch that transports many more bits of data per second will pave the way for speedier Internet connections and movies-on-demand.



■ Pictured above is Dr. Thomas Mossberg, chief technology officer, who believes Templex's optical technology will route data signals faster than current technologies.

Everything carried on optical fiber, whether a phone call, a data file, or video, starts out as electrical impulses. Before these impulses can enter the fiber, they must be converted to optical form. Today, that conversion is done at the local phone company office, using a costly computer—or switch—that modulates a laser so that variations in the light carry the signal. The difficulty comes in separating those different messages to deliver them to their ultimate destination.

Templex Technology Corporation (Eugene, OR) has developed an optical switch that can make this transfer more quickly, increasing the speed of communications. Called SmartSwitch, this technology operates up to 100 times faster than current switches, making it possible to route the equivalent of 500 complete sets of the *Encyclopedia Britannica* in 1 second. This speed increase will save time and money for people and businesses that frequently rely on the Internet as a source of information. Immediate benefits could include cheap two-way videoconferencing and the delivery of movies-on-demand to the home.

Superfast routing. Underlying SmartSwitch technology are unique proprietary encoder/decoder devices that generate and detect ultrahigh-speed optical data packets. The encoding device uses a form of code division multiple access (CDMA) to transmit groups of data bits through multiple channels on a single fiber, with each bit assigned a unique sequence code. These data bits are then funneled through a decoder device, which either continues transmitting them along each channel or selectively reroutes them to new destinations. BMDO's SBIR program funded the development of SmartSwitch technology for new high-speed, all-optical data communications networks.

SmartSwitch optical switching devices are simple in design and cheaper than competing devices. "Templex's CDMA provides multiple communication channels with a single laser source," says Dr. Thomas Mossberg, Templex's chief technology officer. "Competing technologies such as wavelength division multiplexing (WDM) systems, for example, use multiple lasers. In addition, because SmartSwitch uses only one laser, it will be much more reliable than WDM systems."

Templex says there is an enormous potential for SmartSwitch in telecommunications. Telephone and cable TV companies have installed 25 million miles of

fiber-optic cable in the United States and are adding thousands of miles a day. Hundreds of thousands of optical switches are needed to direct traffic on these cables. Templex is discussing potential manufacturing deals with several major telephone companies.

In addition to an optical switching device, Templex is developing an optical dynamic random access memory (ODRAM) product. About the size of a regular 3.5-inch diskette, ODRAM will be capable of providing 100 gigabytes (one billion bytes) of storage capacity with entirely nonmechanical beam steering, resulting in data access times of microseconds (millionths of a second) rather than milliseconds (thousandths of a second) common in magnetic disk storage technology today. It also promises multigigabit-per-second read and write rates.

Capacious memory. Templex's ODRAM technology will be faster than traditional semiconductor random access memory (RAM) and have a greater storage capacity than magnetic media or compact disc read-only memories (CD-ROMs). For example, ODRAM will store up to 100,000 bits of information per spot, compared with CD-ROM's 1 bit per spot. Businesses and government agencies that must quickly access reams of small, individual records could benefit from using Templex's technology. Possible users include banks, insurance companies, libraries, the Internal Revenue Service, and the Social Security Administration.

An ODRAM prototype has recently been completed. It stores between 50 and 100 gigabytes of data at a cost ranging from \$250 to \$500 per gigabyte. Templex is discussing market opportunities with a major data storage system supplier.

In 1995, Templex received start-up funding from Cascadia Pacific Management and the Oregon Technology Development Fund. Recently, the company concluded a venture capital round of financing with a group of prominent U.S.-based high-technology investors, bringing the firm's total capital infusion to over \$5 million. "The new capital funding brings not only additional financing to the firm, but also a broad base of knowledge from its new investors that will drastically shorten time lines for development of our products," says Larry Brice, Templex's president.

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What Does It Mean to You?

Optical switches will help reduce traffic bottlenecks along the information superhighway, enabling the Internet to emerge as a full-blown service or utility carrying many types of media.



What Does It Mean to Our Nation?

Optical switches will speed the creation of Internet commerce, boosting our country's technological edge in the global marketplace.

Tech Trivia

One of the biggest congestion spikes on the Internet can be attributed to NASA's World Wide Web coverage of which event?

- A. The collision of Comet Shoemaker-Levy with Jupiter
- B. The landing of a spacecraft on Mars
- C. The discovery of ice on the moon
- D. The destruction of the space shuttle Challenger

For the answer, see page 72.